INSECT POPULATION RESPONSES TO VEGETATION MANAGEMENT SYSTEMS IN TROPICAL MAIZE PRODUCTION [1]

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ABSTRACT

A series of studies of interactions between weed management systems and insect pests in maize production systems were conducted in two ecological areas of the Atlantic Zone of Costa Rica.

Insect pest damage was reduced and production increased in no-till systems as compared to plowed fields. Spodoptera frugiperda (J. E. Smith) and Diabrotica balteata Leconte colonization incidence was significantly greater in plowed fields. Soil inhabiting pests reduced population and plant vigor more in plowed plots than in no-till plots.

Results imply that no-till techniques are appropriate for the small traditional producer in tropical areas.

INTRODUCTION

Minimum or zero-tillage acreage for crop and pasture production in the United States of America increased from some 12,000,000 hectares in 1972 to nearly 40,000,000 hectares in 1981 (13). This indicates that reduced tillage systems provide distinct advantages in many situations. Frequently mentioned advantages are: high yields, (1,2,11,15,16,17,19), soil and moisture conservation (1,2,4,6,9,11,14,16,17,18,25), reduced energy consumption (1,3,7,10,12, 14,16,17,26), and thus increased economic efficiency (4,10,14,16,17,20,26). Many authors caution that insects and diseases are frequently more problematic, or at least potentially more severe, with no-till systems (8,9,17,18,24,25).

Oregon State University, under an USAID contract, initiated a cooperative weed control research program with the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) in Costa Rica in 1976. This project has concentrated on no-till vegetation management systems for maize, beans, cassava, and various combinations of these crops in humid tropics. This paper discusses the interactions between insects and tillage methods recorded in experiments carried out over a four-year period in the Atlantic Zone of Costa Rica. The area is characterized by 2674mm to 4260mm annual precipitation and 22.3°C to 25.1°C mean annual temperature. Elevation ranges from 250m to 610m.

EXPERIMENTAL RESULTS

Increased grain yields and plant height in no-till treatments in an initial experiment (Table 1) were believed entirely related to physical and chemical phenomena in the soil (23), until increased insect populations were noticed.

Table 1. Yield of shelled maize and plant height 120 days after planting (DAP) with four weed management systems. Guácimo, Costa Rica. 1978, (23).

Treatments	Yield shelled maize (kg/ha)	Plant height (cm)
1. Plowed + linuron + metalachlor (1.0+2.0 kg/ha) Pre + paraquat (0.3 kg/ha) 20 + 40 DAP	2397	233
2. Plowed + paraquat (0.3 kg/ha) 20 + 40 DAP	2959	233
3. Slashed at planting + paraquat (0.2 kg/ha) 20 + 40 DAP	2819	241
4. Glyphosate (1.3 kg a.e./ha) PP + paraquat (0.3 kg/ha) 45 DAP	3034	249
CV = 13.68%		
LSD at P of .05 =	578	17

Farmers in the area corroborated our early observations that insect problems in plowed fields were greater than in non-plowed fields. Thus, an experiment was designed to study the interactions between insects and six vegetation management systems (5). Each system was repeated with and without insect control (Figure 1). Carbofuran (1 kg/ha) was applied at planting and methomyl (0.145 kg/ha) + trichlorfon (0.5 kg/ha) applied to foliage 25, 35 and 45 DAP.

Grain yield in plowed plots (1500 kg/ha) was 49.8% of the average yield (3011 kg/ha) in the 5 no-till systems if insects were not controlled. If insects were controlled, plowed plots produced 68% of the average yield from the no-till systems. Yields were reduced 24.1% in no-till treatments and 44.4% in plowed treatments if insects were not controlled. Apparently, pest damage and perhaps several soil associated phenomena have separate but confounding affects on yield.

Figures 2 and 3 indicate that vegetation management systems strongly affected the number of maize plants damaged by Spodoptera frugiperda (J. E. Smith) and Diabrotica balteata Leconte (5).

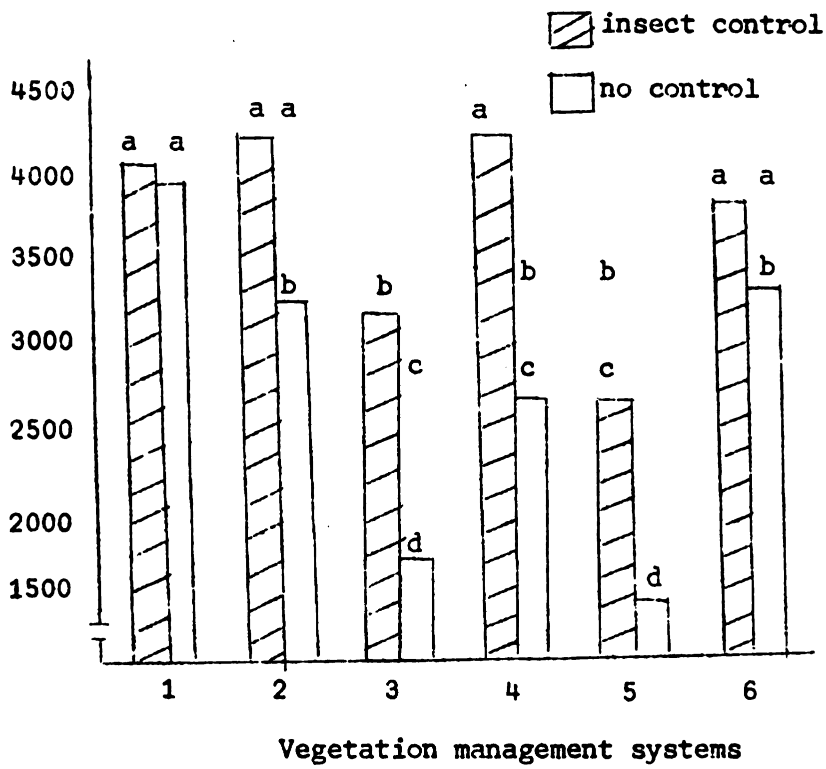
Spodoptera frugiperda populations in system 1 were similar to the plowed system. The weeds in this system were cut at ground level and glyphosate applied to regrowth 22 days later, eliminating the predominant species, Paspalum fasciculatum. The prostrate mulch on the soil surface 12 days after planting (DAP) left maize highly exposed, as in the plowed treatment. Weeds in this treatment did not interfere apreciably with visual and chemical stimuli for insect colonization of the maize.

Increased colonization by D. balteata in plowed plots probably was influenced by insect response to color contrast between the crop and the plowed soil and by preference for oviposition in plowed soil (5).

No significant differences were found among Phyllophaga spp. populations in the soil, although population trends followed weed populations in the various systems.

P. fasciculatum was the predominant weed species when the experiment was initiated. Other species, including Digitaria spp, Eleusine indica, Setaria sp,

Figure 1. Yield of shelled maize for six vegetation managements with and without control of insects 1/. Guápiles, 1979. Adapted from Carballo (5).



1/ Columns with the same letter not different at the 5% level as determined by Duncan's multiple range test.

Systems

1. Glyphosate 1.5 kg/ha on regrowth 20 days after slashing at ground level. Planted 7 days later, with no postemergence weed control.

2. Glyphosate 1.5 kg/ha on regrowth 20 days after slashing 40-60cm high. Planted 7 days later, with no postemergence weed control.

3. Same as No.1, substituting "farmer mix" - MSMA + paraquat + atrazine (4.0 + 0.5 + 1.0 kg/ha).

4. Slashed at ground level day of planting + paraquat + MSMA (0.4 + 2.0 kg/ha) 22 DAP.

5. Plowed-disked + paraquat + 2,4-D + 2,4,5-T (0.4 + 0.4 + 0.4 kg/ha) 22 DAP

6. Slashed at ground level at planting + manual weeding 22 DAP.

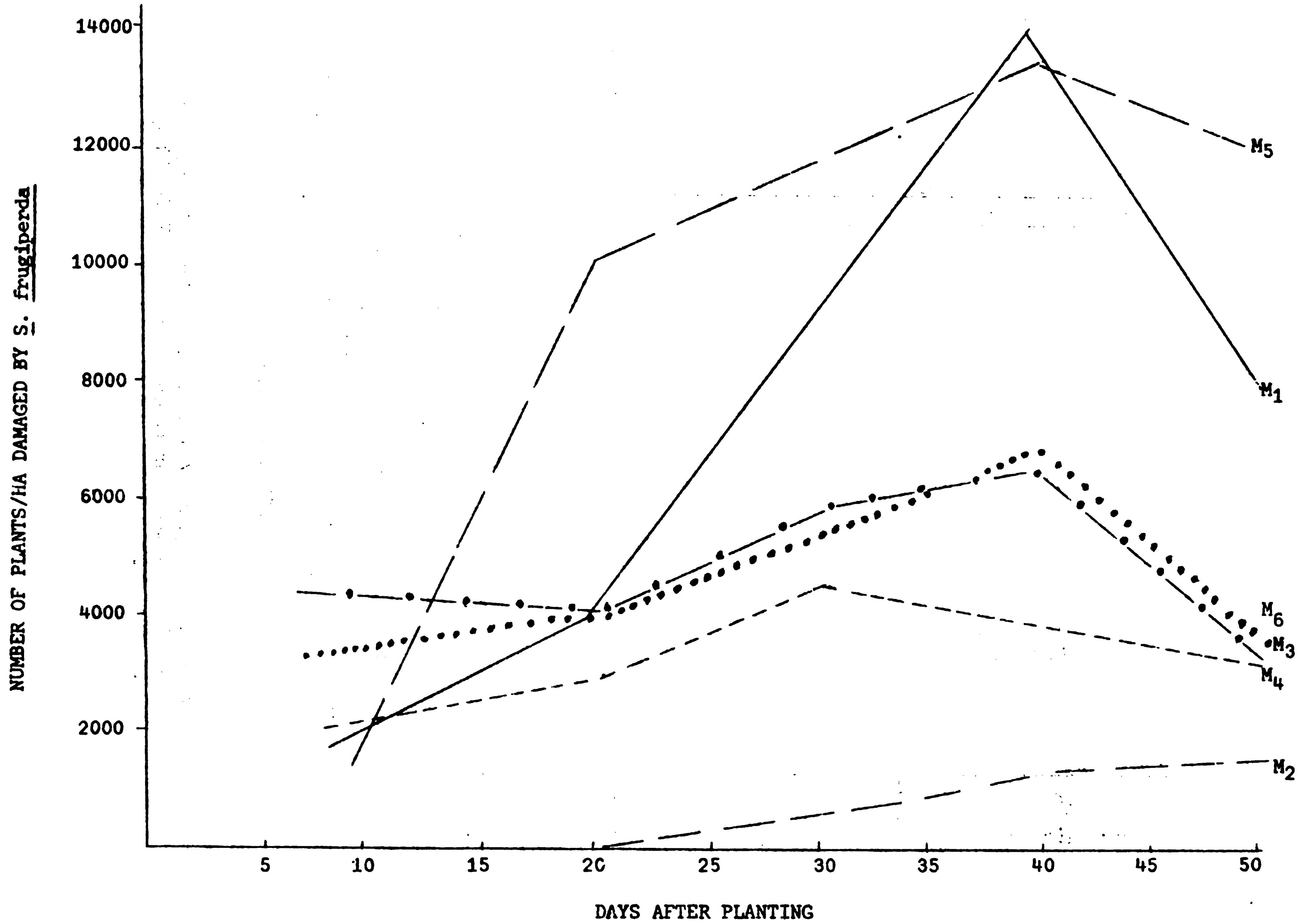


Figure 2. Number of plants damaged by Spodoptera frugiperda during the first 50 days after planting in 6 weed management systems.

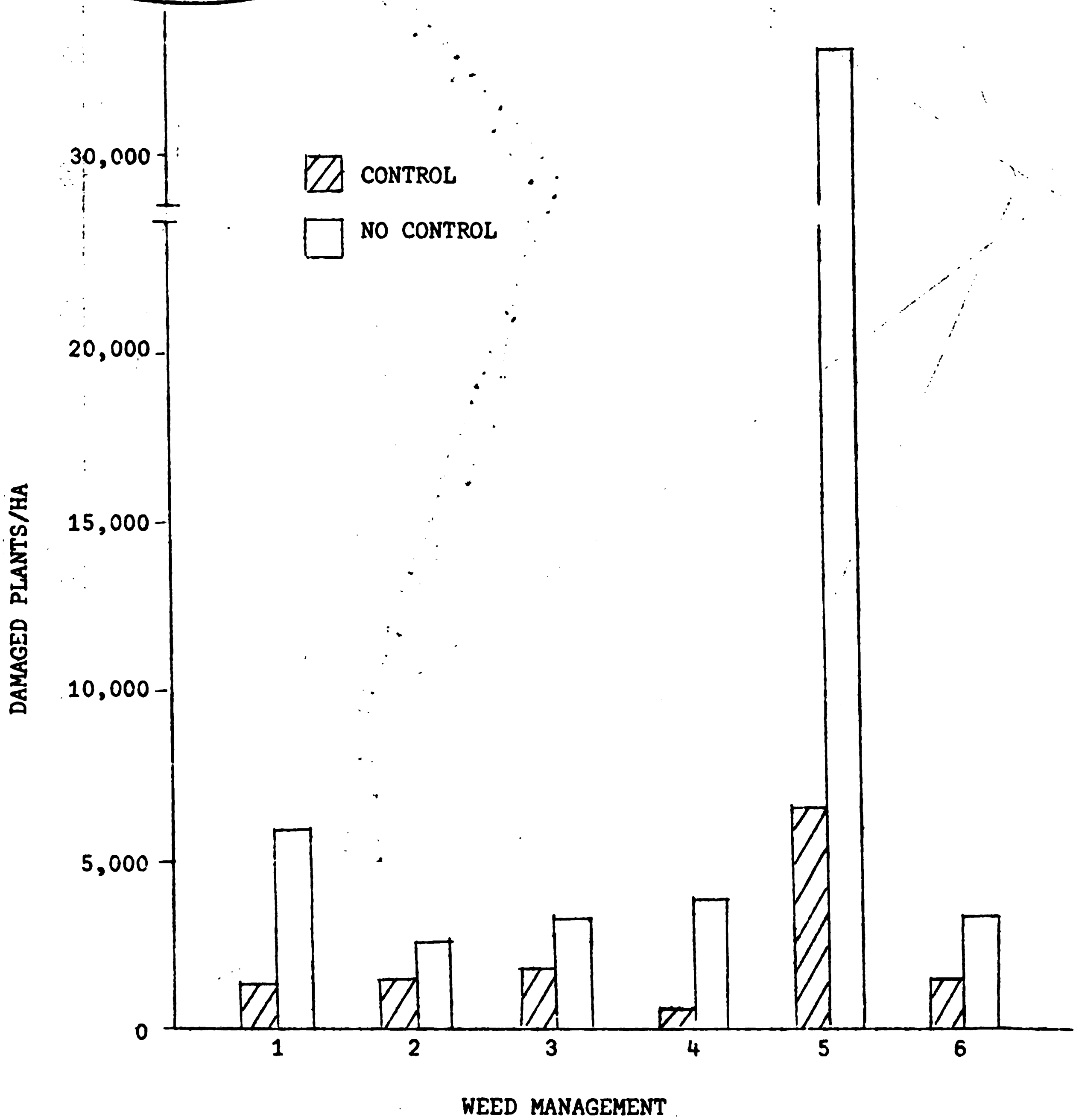


Figure 3. Number of maize plants/ha damaged by <u>Diabrotica balteata</u> 15 DAP, for six weed management systems with and without insect control.

and Borreira sp, composed 10% of the weed complex. Glyphosate reduced grass populations more effectively than the other treatments, Table 2.

Table 2. Number of grass and broadleaf weeds/m^2, 20 and 40 DAP, for six vegetation management systems. Guápiles, 1979

System	20 DAP		40 DAP	
	grass	broadleaf	grass	broadleaf
1	13.8	11.8	21.9	12.9
2	3.5	10.0	13.7	72.5
3	33.6	13.3	39.3	25.9
4	39.1	18.2	30.7	17.4
5	26.9	19.6	21.5	21.0
6	33.4	24.8	34.6	38.2

The regeneration potential of weeds in the humid lowland tropics was demonstrated by rapid recovery of weed populations after weed control. Although weeds were controlled 22 DAP in treatments 3-6, weeds/m^2 40 DAP in all treatments approached levels existing 20 DAP. Weed counts and maize yields were not correlated.

Broadleaf weeds tended to invade in treatments with more effective grass control, but competition from broadleaf weeds was insignificant.

A tillage experiment to study physical-chemical factors in tilled and no-till treatments was established in 1977 on a clayloam soil in Turrialba. The field had been in pastures for 15 years. Panicum maximum and P. fasciculatum were the predominant species. Maize and cassava monocrops, and maize-bean and cassava-bean polycrops were planted during the first two years. In 1979 a study of interactions between insects and vegetation management systems in maize (Table 3) was initiated in the same field (22) Insect control included carbofuran or aldrin applied with the seed (1.0 kg/ha). Foliar control included carboryl spray 10 DAP and granular phoxim applied to whorl.

Table 3. Yield of shelled maize (kg/ha) with six insect controls and two tillage systems. Turrialba, 1980.

Insect control	Tillage System Yield shelled maize (kg/ha)*	
	Plowed	No-till
1. None	2776 e	3617 cd
2. Aldrin in soil	3788 bcd	3617 bcd
3. Aldrin in soil + foliar control	3731 bcd	3812 bcd
4. Carbofuran in soil	4292 abc	4751 a
5. Carbofuran in soil + foliar control	4873 a	4498 ab
6. Foliar control only	3393 de	3763 bc
CV = 13.02%		

*Values followed by the same letter are not different at the 5% level as determined by Duncan's Multiple Range Test.

Unlike the previous experiment, shelled maize yields were the same for both tillage methods when insecticides were applied. However, yields were significantly less in plowed plots without soil insect control. Foliar-feeding insect damage did not reduce yields significantly.

The greater yields in the treatments with carbofuran leave unanswered several questions; did carbofuran physiologically stimulate maize, or does all of the increased yield reflect protection of mazie roots from insects and/or nematodes? A preliminary study in CATIE* indicates that carbofuran does not induce a physiological stimulus in maize.

Plant height and plant population 40 DAP had correlation coefficients with yield of 0.74 and 0.86 respectively. Increased plant height probably reflects superior protection of roots, allowing better nutrient and water uptake. Plant population maintainance reflects protection from soil inhabiting pests.

Response of six cropping systems with two nitrogen levels and two tillage systems were studied in the same field in 1980 (9) . Residual nitrogen following the different cropping systems also was studied in a relay planting of maize.

Maize and common beans both had significantly higher yields in the no-till plots. Lima bean (<u>Phaseolus lunatus</u>) yields were significantly lower for no-till, but slug damage (Mollusca: Gastropoda) in the no-till plots was severe (Table 4).

Increased slug attack in no-till plots was attributed to environmental effects on slug populations. Slug attack was significantly reduced when lima beans were intercropped with maize.

Four fertility levels, no control of insects or carbofuran applied with the seed, and two tillage systems were studied in well drained loam soils in the Atlantic costal area of Guácimo, Costa Rica in 1980 (21). The harmful effects of soil inhabiting insects and tillage were demonstrated (Table 5).

The average yield for the plowed treatments was 2960 kg/ha compared to 4410 in no-till. Insect control increased yields. Yield was correlated significantly with plant population and plant height, two parameters that permit an indirect measure of damages caused by soil inhabiting insects. The fertilizer levels reflect an attempt to evaluate current farmer practices in the

*Phillip Shannon, Personal Communication

Table 4. Number/ha of lima bean plants damaged by slugs and maize plants damaged by *Spodoptera frugiperda*, as monocrops and polycrops under two tillage systems. Turrialba, 1980. Adapted from Jiménez (10).

Tillage-cropping system	Lima bean plants/ha cut by slugs	Maize plants/ha damaged by *S. frugiperda*	Yield of dry seed (kg/ha)	
			Lima b	Maize
-Monocrop				
Plowed				
Lima beans	2220	-	1466	-
Maize	-	14,012	-	2808
No-Till				
Lima bean	24,800	-	756	-
Maize	-	212	-	3958
-Associated-Polycrop				
Plowed				
Lima bean +	80	-	1216	-
Maize	-	11,536	-	2457
No-Till				
Lima bean +	6200	-	692	-
Maize	-	0	-	3421

Table 5. Average yield of unshelled maize for two tillage systems, two levels of insect control, and four fertility levels. Guácimo (San Luis) Costa Rica. 1980 (21).

	KG/HA OF UNSHELLED MAIZE								
	PLOWED				NO-TILL				
	F_1	F_2	F_3	F_4	F_1	F_2	F_3	F_4	Ave.
No insect control	2470	2170	3030	3120	4180	4090	3480	4280	3350
Carbofuran	3050	2840	3370	3670	4250	5680	4350	5000	4030
Ave.		2960				4410			

CV = 18.1%
LSD for tillage = 1380
LSD for insect control = 276

area and thus did not include a wide range of fertilizer rates. The response to fertilizer was minimum. Foliage attacking insects were not apparent in this experiment. Sampling method for detecting soil inhabiting insects (20cm X 20cm X 20cm soil sample around 8 plants/50m^2) did not permit the detection of significantly different insect populations.

CONCLUSIONS

Experiments in two different areas, with different soil types and varied field histories have consistently shown that insects reduced maize grain yields more in plowed fields than in no-till fields.

Soil inhabiting insects (or perhaps nematodes) frequently reduce plant vigor and population in plowed treatments.

The incidence of Spodoptera frugiperda and Diabrotica balteata was much greater in plowed plots. No-till treatments with vegetation cover flat on the soil surface also had increased S. frugiperda attack. Insect damage may be reduced in no-till situations because:

1. The abundance of vegetative materials may provide alternate food sources.
2. The vegetative material provides an habitat for more insect species, including predators.
3. The vegetative cover provides a physical barrier to the free movement of certain insects.
4. The vegetative cover may mask olfactory stimuli.
5. The mulch cover reduces the visual contrast between the crop and the background, as compared to a plowed field.
6. Certain insects prefer to oviposite in plowed fields.

These findings imply that no-till techniques are probably more appropriate for the small traditional producer than mechanization. In addition to providing agronomic benefits such as improved soil and water conservation and greater economic efficiency, the severity of insect attack was reduced. This could reduce insecticide use, reducing potential harm to human health and the environment. Furthermore, if plowing-disking are used to prepare a field for planting maize, insect control should be practiced.

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